

CLAIMS

What is claimed is:

1 1. A method for fabricating a thermal management system for a micro-
2 component device, comprising:
3 overlaying a target substrate with a blank in sheet form;
4 stamping a microchannel structure having a plurality of outer walls
5 enclosing a predefined area from the blank;
6 bonding the microchannel structure to a heat dissipating side opposite from a
7 micro-component device facing side of a first substrate, the micro-component
8 device facing side adapted to thermally engage with the micro-component device;
9 bonding the microchannel structure to a second substrate opposite the first
10 substrate, defining a closed volume microchannel; and
11 substantially filling the microchannel with a fluid thermal interface material.

1 2. The method of claim 1, wherein stamping a microchannel structure having a
2 plurality of outer walls enclosing a predefined area from the blank, comprises:
3 providing a press tool having a predetermined relief structure with cutting
4 blades adapted to cut the blank;
5 pressing the press tool into the blank such that the cutting blades cut through
6 to the target substrate, cutting the blank into a microchannel structure and waste
7 portions, the microchannel structure comprising a plurality of outer walls defining
8 an edge seal enclosing a predetermined area of the target substrate; and
9 removing the waste portions.

1 3. The method of claim 2, wherein providing a press tool having a
2 predetermined relief structure with cutting blades adapted to cut the blank
3 comprises:
4 providing a press tool having a predetermined relief structure with cutting
5 blades adapted to cut the blank, the relief structure having an inner surface between
6 adjacent cutting blades; and

7 wherein pressing the press tool into the blank such that the cutting blades cut
8 through to the target substrate, cutting the blank into a microchannel structure and
9 waste portions, comprises:

10 pressing the press tool into the blank such that the cutting blades cut through
11 to the target substrate cutting the blank into a microchannel structure and waste
12 portions, the inner surface applying a predetermined compressive force onto the
13 microchannel structure to facilitate a fluid-tight diffusion bond between the
14 microchannel structure and the target substrate.

1 4. The method of claim 1, wherein bonding the microchannel structure to a first
2 substrate comprises:

3 bonding the microchannel structure to the target substrate, wherein the target
4 and first substrates are one and the same.

1 5. The method of claim 4, wherein bonding the microchannel structure to a first
2 substrate comprises:

3 applying a compressive force between the first substrate and the
4 microchannel structure to effect a fluid-tight diffusion bond between the first
5 substrate and the microchannel structure.

1 6. The method of claim 5, wherein applying a compressive force between the
2 target substrate and the microchannel structure to effect a fluid-tight diffusion bond
3 between the target substrate and the microchannel structure comprises:

4 applying a compressive force at an elevated temperature below the melt
5 temperature of either the target substrate and the microchannel structure over a
6 predetermined period of time to effect a fluid-tight diffusion bond between the
7 target substrate and the microchannel structure.

1 7. The method of claim 1, wherein bonding the microchannel structure to a
2 second substrate opposite the first substrate, defining a closed volume microchannel
3 comprises:

4 providing a second substrate onto the microchannel structure opposite the
5 target substrate; and
6 applying a predetermined compressive force to the second substrate and
7 microchannel structure sufficient to provide a fluid-tight diffusion bond there
8 between.

1 8. The method of claim 7, wherein applying a predetermined compressive force
2 to the second substrate and microchannel structure sufficient to provide a fluid-tight
3 bond there between comprises:

4 applying a predetermined compressive force at an elevated temperature
5 below the melt temperature of either the target substrate, second substrate, and the
6 microchannel structure, over a predetermined period of time to effect a fluid-tight
7 diffusion bond between the second substrate and the microchannel structure.

1 9. The method of claim 1, wherein substantially filling the microchannel with a
2 fluid thermal interface material comprises:
3 substantially filling the microchannel with an indium alloy that is liquid at a
4 predetermined micro-component device operating temperature.

1 10. The method of claim 1, further comprising thermally coupling the micro-
2 component device facing side of the first substrate with a heat-producing side of the
3 micro-component device.

1 11. The method of claim 10, wherein thermally coupling the micro-component
2 device facing side of the first substrate with a heat-producing side of the micro-
3 component device comprises:

4 thermally coupling the micro-component device facing side of the first
5 substrate with a backside of a microelectronic die, the microelectronic die
6 comprising integrated circuits.

1 12. The method of claim 11, further comprising:

2 thermally coupling the fluid thermal interconnect material with one or more
3 thermal dissipation devices selected from the group consisting of heat pipe, thermal
4 dissipation fins, fan, heat exchanger, and flat plate.

1 13. A micro-component device package, comprising:

2 a micro-component device comprising a die and a carrier substrate, the die
3 having a backside, the die being electrically interconnected with the carrier
4 substrate; and

5 a thermal management system in thermal engagement with the backside, the
6 thermal management system comprising:

7 a first substrate having a die facing side and an opposite heat
8 dissipation side, the die facing side thermally coupled to the back side of the
9 die;

10 a microchannel structure having a plurality of outer walls enclosing a
11 predefined area, the microchannel structure coupled to the heat dissipation
12 side of the first substrate;

13 a second substrate, the second substrate coupled to the microchannel
14 structure, the first substrate, microchannel structure and the second substrate
15 defining a closed volume microchannel; and

16 a thermal interface material disposed within the closed volume
17 microchannel.

1 ~~14~~ 14. The micro-component device package of claim 13, wherein the first
2 substrate includes an integrated heat spreader and the second substrate includes a
3 heat sink.

1 15. The micro-component device package of claim 13, wherein the thermal
2 management system further comprises:

3 an inlet aperture through the outer wall in fluid communication with the
4 microchannel; and

5 a vent aperture through the second substrate or the outer wall, the vent
6 aperture in fluid communication with the microchannel.

1 16. The micro-component device package of claim 15, wherein the vent aperture
2 includes a semi permeable membrane plug adapted to allow the passage of gas but
3 not the fluid thermal interface material.

1 17. The micro-component device package of claim 15, wherein the thermal
2 management system further comprises:
3 a thermal interface material supply line coupled to the inlet aperture;
4 a thermal interface material discharge line coupled to the vent aperture; and
5 a micropump coupled to the supply line and the discharge line, the
6 micropump configured to provide a pressure differential to circulate the fluid
7 thermal interface material from the supply line, through the microchannel, and to the
8 discharge line.

1 18. The micro-component device package of claim 17, wherein the thermal
2 management system further comprises a heat exchanger in fluid communication
3 with the microchannel, the heat exchanger adapted to dissipate thermal energy from
4 the fluid thermal interface material.

1 19. The micro-component device package of claim 13, wherein the thermal
2 interface material is selected from a group including indium alloy, Ga-In-Sn Alloy,
3 Cesium Francium, and Rubidium.

1 20. The micro-component device package of claim 13, wherein the micro
2 component device is an integrated circuit.

1 21. A system comprising:
2 a selected one of a digital signal processor and a graphics processor; and
3 a micro-component device package coupled to the selected one of a digital
4 signal processor and a graphics processor, including
5 a micro-component device comprising a die and a carrier substrate, the
6 die having a backside, the die being electrically interconnected with
7 the carrier substrate; and
8 a thermal management system in thermal engagement with the backside,
9 the thermal management system comprising:
10 a first substrate having a die facing side and an opposite heat
11 dissipation side, the die facing side thermally coupled to the
12 back side of the die;
13 a microchannel structure having a plurality of outer walls
14 enclosing a predefined area, the microchannel structure
15 coupled to the heat dissipation side of the first substrate;
16 a second substrate, the second substrate coupled to the
17 microchannel structure, the first substrate, microchannel
18 structure and the second substrate defining a closed volume
19 microchannel; and
20 a thermal interface material disposed within the closed volume
21 microchannel.

1 22. The system of claim 21, wherein the first substrate of the thermal
2 management system of the micro-component device package includes an integrated
3 heat spreader and the second substrate includes a heat sink.

1 23. The system of claim 21, wherein the thermal management system further
2 comprises:
3 an inlet aperture through the outer wall in fluid communication with the
4 microchannel; and

5 a vent aperture through the second substrate or the outer wall, the vent
6 aperture in fluid communication with the microchannel.

1 24. The system of claim 23, wherein the vent aperture includes a semi
2 permeable membrane plug adapted to allow the passage of gas but not the fluid
3 thermal interface material.

1 25. The system of claim 23, wherein the thermal management system further
2 comprises:
3 a thermal interface material supply line coupled to the inlet aperture;
4 a thermal interface material discharge line coupled to the vent aperture; and
5 a micropump coupled to the supply line and the discharge line, the
6 micropump configured to provide a pressure differential to circulate the fluid
7 thermal interface material from the supply line, through the microchannel, and to the
8 discharge line.

1 26. The system of claim 25, wherein the thermal management system further
2 comprises a heat exchanger in fluid communication with the microchannel, the heat
3 exchanger adapted to dissipate thermal energy from the fluid thermal interface
4 material.

1 27. The system of claim 21, wherein the thermal interface material is selected
2 from a group including indium alloy, Ga-In-Sn Alloy, Cesium Francium, and
3 Rubidium.